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# Prevalence and predictors of alcohol use during pregnancy: findings from international multicentre cohort studies

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## ABSTRACT

**Objectives:** To compare the prevalence and predictors of alcohol use in multiple cohorts.

**Design:** Cross-cohort comparison of retrospective and prospective studies.

**Setting:** Population-based studies in Ireland, the UK, Australia and New Zealand.

**Participants:** 17 244 women of predominantly Caucasian origin from two Irish retrospective studies (Growing up in Ireland (GUI) and Pregnancy Risk Assessment Monitoring System Ireland (PRAMS Ireland)), and one multicentre prospective international cohort, Screening for Pregnancy Endpoints (SCOPE) study.

**Primary and secondary outcome measures:** Prevalence of alcohol use pre-pregnancy and during pregnancy across cohorts. Sociodemographic factors associated with alcohol consumption in each cohort.

**Results:** Alcohol consumption during pregnancy in Ireland ranged from 20% in GUI to 80% in SCOPE, and from 40% to 80% in Australia, New Zealand and the UK. Levels of exposure also varied substantially among drinkers in each cohort ranging from 70% consuming more than 1–2 units/week in the first trimester in SCOPE Ireland, to 46% and 15% in the retrospective studies. Smoking during pregnancy was the most consistent predictor of gestational alcohol use in all three cohorts, and smokers were 17% more likely to drink during pregnancy in SCOPE, relative risk (RR) =1.17 (95% CI 1.12 to 1.22), 50% more likely to drink during pregnancy in GUI, RR=1.50 (95% CI 1.36 to 1.65), and 42% more likely to drink in PRAMS, RR=1.42 (95% CI 1.18 to 1.70).

**Conclusions:** Our data suggest that alcohol use during pregnancy is prevalent and socially pervasive in the UK, Ireland, New Zealand and Australia. New policy and interventions are required to reduce alcohol prevalence both prior to and during pregnancy. Further research on biological markers and conventions for measuring alcohol use in pregnancy is required to improve the validity and reliability of prevalence estimates.

## Strengths and limitations of this study

- Our study goes beyond measurement of alcohol use during pregnancy with just one cohort or one measurement method, but examines prevalence and predictors using different measurement techniques in similar populations.
- The study had a large sample size of almost 18 000 women, and we were able to examine prevalence using different modes of administration (anonymised, self-administered, postal survey, trained government interview, antenatal midwife-collected data) and timing of administration including prospective and retrospective measurement.
- However, because we relied on self-reported alcohol consumption, reporting and recall biases may exist in our study. Furthermore, differences in mode and timing of data collection could explain variation in estimates between studies.
- Our analysis only included live born babies, and thus, there is a possibility that we have excluded women with the heaviest drinking patterns, since failure to give birth to a baby could have resulted from heavy alcohol consumption; for example, miscarriage occurring due to chronic alcohol use or binge drinking in early pregnancy.
- Participants in our study may also be more advantaged than the general population, and thus, the generalisability of our findings to all pregnancies, or more diverse populations, may be reduced.

## INTRODUCTION

Worldwide, the majority of clinical and government guidelines advocate for pregnant women to abstain from alcohol consumption during pregnancy due to potential adverse effects on pregnancy outcomes.[1–4] However, although the National Institute of Health and Care Excellence (NICE) guidelines in the UK advise abstinence from alcohol in

early pregnancy due to increased risk of miscarriage, it is noted that 1–2 units up to twice per week have not been shown to be harmful to the unborn baby, if women choose to drink.[5]

Conflicting results on the effects of gestational alcohol consumption on offspring health outcomes and subsequently, lack of coherence in clinical and government guidelines stem from a lack of biological markers of light or moderate alcohol use during pregnancy. Thus, studies of associations with offspring health outcomes rely on self-reported maternal alcohol consumption which may be biased by reporting and recall biases. For example, estimates of prevalence of alcohol use during pregnancy and its associated predictors in existing cohort data are highly variable and range from 36% in the Millennium Cohort Study (MCS)[6] to almost 60% in the Avon Longitudinal Study of Parents and Children (ALSPAC).[7] Consequently, whether exposure and its predictors are reliably measured in observational studies is difficult to decipher, and thus, approaches which reveal the validity and reliability of estimates and predictors are required.

Cross-cohort comparisons may be a useful way to examine plausible and valid self-reported prevalence estimates and predictors. Comparing multiple cohort estimates within the same population allows the validity of prevalence estimates and predictors of alcohol use to be compared when measured using different techniques; if prevalence is accurately reported and not subject to substantial recall and reporting biases, prevalence and predictors should be mostly consistent across studies. Comparing subpopulation estimates within the same cohort allows for population variation in alcohol prevalence and predictors to be compared when exposure measurement is constant; if prevalence and predictors vary substantially across countries within the same study using the same measurement methods, insights into the impact of culture and attitudes on alcohol consumption, or reporting of alcohol, can be revealed. Taken together, such techniques may provide increased insight into plausible prevalence estimates of alcohol use during pregnancy, improved alcohol exposure measurement during pregnancy, and increased understanding of the social patterns of alcohol use across cohorts. In turn, this evidence can be used to inform antenatal care guidelines on alcohol use.

The objectives of this study were to compare the prevalence of alcohol use across three cohorts; Growing up in Ireland (GUI),[8 9] Screening for Pregnancy Endpoints (SCOPE) study[10] and Pregnancy Risk Assessment Monitoring System (PRAMS) Ireland.[11] GUI and PRAMS measured gestational alcohol use retrospectively, while SCOPE obtained measures of alcohol use during pregnancy. Second, we compared the characteristics associated with alcohol use in all three studies and within SCOPE countries (New Zealand, Ireland, Australia and the UK) in order to examine cross-cohort and cross-country consistency in the prevalence and predictors of gestational alcohol use.

## METHODS

### Study population

#### Growing up in Ireland

The National Longitudinal Study of Children is the first longitudinal study of its kind that focuses on the developmental trajectories of children in Ireland.[8] Participants were sampled from the state child benefit register (>20 000 primary care givers sampled from approximately 41 000 on the register over the period 1 December 2007 to 30 June 2008) using a simple systematic selection procedure prestratifying by parental marital status, country of residence, nationality and number of children.[8] Surveys were completed with the primary and secondary caregivers of 11 134 infants aged 6–9 months, from September 2008 to April 2009.[8] This represented almost a quarter of all births in Ireland over that period.[8] Surveys were administered by trained study personnel in the home of the caregivers through a face-to-face interview.[8] Non-biological mothers or male primary caregivers who participated in the study were excluded from the present analysis (0.3%). Biological mothers who did not complete the questionnaire were also excluded from the present study (0.1%). All participants gave informed consent prior to participation in the study.

#### Screening for Pregnancy Endpoints

SCOPE is a prospective, multicentre cohort study with the principal aim of developing screening tests to predict pre-eclampsia, small for gestational age (SGA) infants, and spontaneous preterm birth.[10] Participants were healthy nulliparous females with singleton pregnancies (n=8531 originally approached to participate) of which 5628 were recruited between November 2004 and February 2011 in Auckland, New Zealand; Adelaide, Australia; Cork, Ireland; and Manchester, Leeds and London, UK, as previously described.[10 12] Women were excluded if they were considered at high risk of pre-eclampsia, delivery of a SGA infant, or spontaneous preterm birth, because of underlying medical conditions, gynaecological history, three or more previous miscarriages, three or more terminations of pregnancy, or had received interventions, such as aspirin, that might modify pregnancy outcome.[10] Study participants were interviewed and examined by study research midwives at 15 and 20 weeks of gestation. At the time of interview, data were entered on an internet-accessed central database with a complete audit trail (MedSciNet).[13] Pregnancy information and pregnancy outcome data were collected prospectively by research midwives. All data entries were individually checked (including data entry errors in the lifestyle questionnaire), and a customised software program was used to detect any systematic data entry errors. All participants gave informed consent prior to participation in the study. Only participants who delivered a live born baby were included in the present analysis.

### PRAMS Ireland

The aim of PRAMS was to measure the prevalence of a wide range of maternal health behaviours and experiences before, during and after pregnancy. The sample for the study was derived using hospital discharge records of live births at Cork University Maternity Hospital, a large urban obstetric hospital in the South of Ireland where almost 9000 live births per year occur. A constant sampling fraction of 1 in 2 records alternately sampled 1212 from a sampling frame of approximately 2450 mother–infant pairs discharged between 14 May 2012 and 18 August 2012. Of these, 718 (61%) women responded and were included in the present analysis. Mothers of stillbirths, neonatal deaths (n=3) and early and late miscarriages were planned exclusions (none identified), as the objective of the study was to characterise maternal behaviours and experiences in women with live births. Women were invited to participate by post and were sent three postal surveys, a reminder letter and a text reminder. The PRAMS questionnaire was based on PRAMS Phase 6 questions covering sociodemographics, health behaviours and experiences before, during and after pregnancy,[14] and detailed information on dose, pattern and timing of alcohol exposure for the 3 months before pregnancy, and in each trimester was based on the work of O'Leary *et al*, 2009, and described in detail elsewhere.[11 15] On date of receipt of the first survey, mothers were between 2 and 5 months postpartum. On the date of receipt of the final PRAMS survey, mothers were between 7 and 9 months postpartum. Thus, respondents of the survey were anywhere between 2 and 9 months postpartum. PRAMS used an opt-out consent system whereby women who did not wish to participate in the survey were permitted to opt out at the beginning of the study. Women who did not opt out were treated as willing participants.

## Assessment of alcohol

### Growing up in Ireland

Women were asked, separately, if they drank in each trimester of pregnancy. Women who reported alcohol use during pregnancy were asked how much on average they drank per week (pints of beer or cider, glasses of wine, measures of spirits or alcopops) in each trimester.

### Screening for Pregnancy Endpoints

Alcohol consumption was reported as units consumed per week. At the 15-week interview, participants were asked 'Were you drinking alcohol prior to pregnancy?', 'Were you drinking alcohol earlier in the pregnancy in the first trimester?' and finally 'Are you still drinking alcohol?'. If the participants answered 'yes' to any of the above, the amount of alcohol was then quantified including number of units and binges per week. Participants who confirmed that they had consumed alcohol during pregnancy were asked when they stopped drinking. At 20 weeks' gestation, women were asked the number of units of alcohol per week consumed at 20 weeks' gestation and the number of binges taken between the 15-week and 20-week interviews.

### Pregnancy risk assessment monitoring system

Women were asked to report the number of occasions per week or month alcohol was consumed ranging from never, less than 1 occasion per month, 1–2 occasions per month, 1–2 occasions per week, 3–4 occasions per week and 5 or more occasions per week for the 3 months before pregnancy, and each trimester separately. For the number of occasions indicated in each time period, women were asked to indicate the number of glasses or bottles of beer, wine (100 mL), alcopop, sherry or port, and spirits or liqueurs consumed per occasion.

## Comparing and categorising alcohol use

Although the measurement of alcohol use during pregnancy varied across the studies, we standardised classification across each cohort to ensure categories in each study were comparable (note that some findings on alcohol use in PRAMS and SCOPE have been published previously using different category definitions and in less detail than explored here).[15 16] For this study, one unit of alcohol was equivalent to approximately 8–10 g of absolute alcohol (slight variation across studies) equating to one glass of wine (approximately 100–125 mL), one small glass of sherry, a single nip of spirits, or half a pint of lager (regular strength). A can or small bottle/glass of regular-strength beer (300–330 mL, 4–5% alcohol) was equivalent to 1.5 units of alcohol, and a bottle of alcohol pop was equivalent to 2 units of alcohol. Where prepregnancy alcohol consumption was reported, it was defined as consumption of any alcohol in the 3 months prior to pregnancy. Where quantity of alcohol before pregnancy and by trimester was available, alcohol intake was classified as occasional (1–2 units/week), low (3–7 units/week), moderate (8–14 units/week) and heavy (greater than 14 units/week). Median units of exposure were calculated since alcohol is not normally distributed. Binge consumption was defined as six or more standard units per occasion.

In GUI and PRAMS, any alcohol consumption or any binge consumption was defined as consumption of alcohol in the first, second or third trimester, or consumption of a binge in any of the trimesters (note, binge alcohol consumption data not available in GUI). Binge alcohol use by trimester was defined as any binge alcohol use in the first, second or third trimester separately. Alcohol use before pregnancy was not available in GUI. In SCOPE, any alcohol consumption included any alcohol consumed from conception up to the 20-week interview, including any binge consumption. First trimester use was reported at the 15-week SCOPE visit. For second trimester use, consumption in the week preceding the 15-week SCOPE visit and preceding the 20-week SCOPE visit, were combined and divided by two to obtain a weekly average consumption which was subsequently categorised as occasional, low, moderate or

heavy, as described. Binge drinking in the second trimester was defined as reporting a binge in the week prior to the 15-week SCOPE visit, or between the 15-week and 20-week SCOPE visit.

### Statistical analysis

We examined the association between low birth weight and preterm birth (traditionally examined in relation to the effects of gestational alcohol use) and common confounders of these associations and alcohol use during pregnancy (including age, ethnicity, education, marital status, parity, body mass index (BMI), smoking) since these are characteristics by which social behaviours such as alcohol use are often patterned, and characteristics which are commonly examined as predictors of alcohol use. In all analyses, covariates (age, education, ethnicity, marital status, parity, delivery mode, smoking, BMI, preterm birth and birth weight) were categorised in an identical manner for comparability (see table 1 for categories).

All statistical analyses were conducted in Stata V.12. We used frequencies to describe the characteristics of each cohort and compare reported drinking in all three studies and across SCOPE countries. We used log linear binomial regression to examine the relative risk of alcohol consumption during pregnancy in relation to sociodemographic characteristics in each cohort and in each SCOPE country. Log linear binomial regression was chosen because when an outcome variable is common (>5%), logistic regression tends to overestimate the association between the independent variable of interest and the outcome. In GUI, as age appeared to have a

**Table 1** Characteristics of women participating in GUI (2008, 2009), SCOPE Ireland (2008–2011) and PRAMS Ireland (2012) by their pregnancy alcohol consumption

| | GUI n=10 953 | | | SCOPE Ireland n=1766 | | | PRAMS n=718 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Alcohol | | | Alcohol | | | Alcohol | | |
| | Yes n=2198 | No n=8755 | p Value | Yes n=1444 | No n=322 | p Value | Yes n=324 | No n=394 | p Value |
| Age (years) | | | | | | | | | |
| <20 | 19 (10) | 169 (90) | <0.001 | 30 (82) | 7 (18) | 0.3 | 2 (50) | 2 (50) | 0.01 |
| 20–24 | 130 (13) | 908 (87) | | 137 (83) | 29 (17) | | 4 (17) | 19 (83) | |
| 25–29 | 337 (15) | 1938 (85) | | 433 (80) | 110 (20) | | 53 (38) | 85 (62) | |
| 30–39 | 1528 (23) | 5046 (77) | | 828 (83) | 164 (17) | | 248 (49) | 255 (51) | |
| >40 | 184 (27) | 500 (73) | | 16 (73) | 6 (27) | | 17 (44) | 22 (56) | |
| Education | | | | | | | | | |
| Second | 727 (15) | 4004 (85) | <0.001 | 1286 (82) | 279 (18) | 0.7 | 47 (40) | 72 (60) | 0.1 |
| Tertiary | 1470 (24) | 4551 (76) | | 158 (81) | 37 (19) | | 277 (47) | 307 (53) | |
| Ethnicity | | | | | | | | | |
| Caucasian | 2160 (22) | 7868 (78) | <0.001 | 1433 (83) | 286 (17) | <0.001 | 316 (47) | 253 (53) | <0.01 |
| Other | 36 (5) | 657 (95) | | 11 (27) | 30 (73) | | 3 (10) | 26 (90) | |
| Marital status | | | | | | | | | |
| Married | 1644 (22) | 6021 (78) | <0.001 | 1277 (81) | 296 (19) | <0.01 | 306 (46) | 355 (54) | 0.4 |
| Single | 554 (18) | 2540 (82) | | 167 (89) | 20 (11) | | 18 (39) | 28 (61) | |
| Parity | | | | | | | | | |
| 0 | 760 (18) | 3401 (82) | <0.001 | 1450 (82) | 318 (18) | – | 128 (46) | 151 (54) | 0.97 |
| 1+ | 1438 (22) | 5160 (78) | | – | – | – | 194 (46) | 230 (54) | |
| Smoking | | | | | | | | | |
| Yes | 445 (24) | 1386 (76) | <0.001 | 448 (92) | 38 (8) | <0.001 | 77 (55) | 63 (45) | 0.01 |
| No | 1753 (20) | 7174 (80) | | 996 (78) | 279 (22) | | 204 (43) | 272 (57) | |
| BMI (kg/m$^2$) | | | | | | | | | |
| <18.5 | 52 (18) | 232 (82) | <0.001 | 838 (81) | 194 (19) | 0.2 | 9 (36) | 16 (64) | 0.5 |
| 18.5–24.99 | 1143 (22) | 4132 (78) | | 17 (82) | 4 (18) | | 220 (48) | 237 (52) | |
| 25.0–29.9 | 626 (21) | 2402 (79) | | 419 (85) | 74 (15) | | 69 (46) | 81 (54) | |
| >30 | 275 (17) | 1376 (83) | | 170 (79) | 44 (21) | | 21 (41) | 31 (59) | |
| Preterm birth | | | | | | | | | |
| Yes | 113 (16) | 585 (84) | <0.01 | 67 (79) | 18 (21) | 0.4 | 15 (41) | 22 (60) | 0.5 |
| No | 2081 (21) | 7947 (79) | | 1377 (82) | 298 (18) | | 309 (46) | 360 (54) | |
| Birth weight | | | | | | | | | |
| <2500 g | 86 (15) | 500 (85) | <0.001 | 1384 (82) | 302 (18) | 0.8 | 14 (38) | 310 (62) | 0.3 |
| >/=2500 g | 2095 (21) | 7963 (79) | | 60 (81) | 14 (19) | | 23 (46) | 360 (54) | |

All differences tested with $\chi^2$ test for categorical variables.
BMI, body mass index; GUI, Growing up in Ireland; PRAMS, Pregnancy Risk Assessment Monitoring System; SCOPE, Screening for Pregnancy Endpoints.

linear effect on alcohol, we repeated the model without specifying age as categorical variable to examine a potential trend in the association between age and alcohol use. In the analysis of SCOPE countries, UK centres (Manchester, Leeds and London) were combined. All participants provided written informed consent.

## RESULTS

Eleven thousand one hundred and thirty-four participants were recruited to the GUI study of which 10 953 were included in the present analysis after exclusion of male primary caregivers and women who did not answer the sensitive questionnaire. Five thousand five hundred and seventy-three participants with live births in SCOPE were included (99% of total cohort), 1766 of which occurred in SCOPE Ireland. All PRAMS (n=718) respondents were included in the analysis.

Online supplementary table S1 describes the overall participant characteristics of each study. Table 1 shows reporting of alcohol use by sociodemographics in each cohort. In addition to the marked variation in reporting of alcohol use across cohorts, reporting of alcohol use varied considerably across sociodemographics and health characteristics in each cohort. For example, there was evidence of strong social gradients in alcohol consumption for all characteristics in GUI which were not apparent in SCOPE and PRAMS.

SCOPE had the highest overall reported prevalence of alcohol both pre-pregnancy (90% vs 77% in PRAMS) and during pregnancy (82% vs 46% in PRAMS) (table 2). GUI reported the lowest overall consumption of alcohol use during pregnancy at 20%. SCOPE participants also reported the highest overall consumption levels both pre-pregnancy and during pregnancy, and the highest binge consumption before (59%) and during pregnancy (45%). By the second trimester, reported prevalence and reported consumption levels in SCOPE (29%) were almost equal to PRAMS (31%). Examining changes between the first and second trimesters, SCOPE alcohol prevalence dropped from 82% to 29% consumption between the first and second trimesters, although PRAMS and GUI alcohol consumption stayed relatively constant across all three trimesters at 30% in PRAMS and 10–15% in GUI. Additionally, among the SCOPE participants who continued to drink in the second trimester, there were also substantial reductions in the levels of drinking (70% drinking greater than 1–2 units/week in the first trimester compared with 2% in the second trimester).

Table 3 shows the characteristics associated with alcohol consumption in each cohort. Compared with Caucasian ethnicities, non-Caucasian women in all cohorts were less likely to drink alcohol during pregnancy. Smoking was related to greater risk of consuming alcohol during pregnancy in all three cohorts (RR range from 1.17 to 1.50 for the three cohorts). Younger age was related to lower risk of alcohol use in GUI, and women aged greater than 39 years were more likely to drink alcohol during pregnancy compared with women aged 30–39 years; with evidence of a linear association, overall, between age and gestational alcohol use (p value for trend <0.05) in GUI. Having a second-level education, being multiparous, and having a BMI >30 were related to lower risk of alcohol use during pregnancy in GUI. In SCOPE, single women were more likely to drink alcohol during pregnancy. In relation to outcomes commonly examined in relation to the effects of gestational alcohol use, delivery of a low birth weight infant was not associated with alcohol use in SCOPE; however, in both retrospective cohorts, we found evidence that women who delivered low birth weight infants were less likely to drink alcohol (albeit with CIs spanning the null). For preterm birth, we did not find strong evidence of an association with alcohol use in any of the three cohorts.

Table 4 shows the distribution of alcohol use across each of the four participating countries in SCOPE where log linear binomial regression was used to examine the characteristics associated with alcohol consumption in each cohort adjusted for other variables in the table. Reported alcohol use before and during pregnancy was high in all centres (>40%), but prevalence and quantity of consumption varied substantially by SCOPE centre (p<0.05 for differences in all indices of pre-pregnancy and early pregnancy alcohol consumption). Ireland had the highest prevalence of any alcohol consumption pre-pregnancy (90%) and during pregnancy (82%), and the highest reported binge consumption before (59%) and during (45%) pregnancy. Reported alcohol consumption dropped substantially for all countries in the second trimester as did reported binge consumption. In multivariate log linear binomial regression, factors associated with alcohol use consistently in each SCOPE centre were smoking during pregnancy (all countries) and ethnicity (Ireland, the UK and New Zealand). Other factors that were related to alcohol use but less consistently so, were age, marital status and education (New Zealand Centre only) (table 5).

## DISCUSSION

Our findings show a high prevalence of alcohol use during pregnancy (ranging from 20% to 80% in Ireland), from 40% upwards in the UK, Australia and New Zealand, and high levels of binge drinking during pregnancy (in excess of 45% in the Irish centre of the SCOPE cohort). These findings illustrate low adherence to alcohol guidelines advising complete abstinence from alcohol during pregnancy in Ireland,[1] New Zealand[2] and Australia, and NICE guidelines in the UK advising consumption of no more than 1–2 units once or twice per week.[5] We found that this high prevalence was, in general, pervasive across all social groups, and of the predictors of alcohol consumption examined, smoking

Table 2 Prevalence of alcohol consumption in GUI (2008, 2009), SCOPE Ireland (2008–2011) and PRAMS Ireland (2012)

| | GUI n=10 953 n (%) | SCOPE Ireland n=1766 n (%) | PRAMS n=718 n (%) |
|---|---|---|---|
| Pre-pregnancy alcohol consumption | *Not recorded* | 1586 (90) | 545 (77) |
| Non-drinkers pre-pregnancy | *Not recorded* | 180 (10) | 173 (23) |
| Severity of consumption (units/week)* | | | |
| 1–2 | *Not recorded* | 287 (18) | 168 (43) |
| 3–7 | *Not recorded* | 602 (38) | 96 (24) |
| 8–14 | *Not recorded* | 451 (28) | 73 (19) |
| >14 | *Not recorded* | 247 (16) | 58 (15) |
| Median (IQR) | *Not recorded* | 6 (3, 11) | 4 (1, 10) |
| Pre-pregnancy binging | *Not recorded* | 1044 (59) | 134 (24) |
| Any alcohol in pregnancy | 2198 (20) | 1444 (82) | 325 (46) |
| Non-drinkers in pregnancy | 8755 (80) | 322 (18) | 383 (54) |
| Binge (any in pregnancy) | *Not recorded* | 795 (45) | 23 (4) |
| First trimester alcohol consumption | 1127 (11) | 1415 (80) | 211 (30) |
| Non-drinkers in first trimester | 9826 (89) | 351 (20) | 507 (70) |
| Severity of consumption (units/week)* | | | |
| 1–2 | 572 (54) | 424 (30) | 142 (85) |
| 3–7 | 332 (31) | 600 (42) | 11 (7) |
| 8–14 | 117 (11) | 266 (19) | 8 (5) |
| >14 | 41 (4) | 125 (9) | 7 (4) |
| Median (IQR) | 2 (2, 2) | 4 (2, 7.5) | 1 (1, 2) |
| Binge first trimester (yes) | *Not recorded* | 795 (45) | 21 (3) |
| Second trimester alcohol consumption | 1585 (15) | 500 (29) | 216 (31) |
| Non-drinkers in second trimester | 9368 (85) | 1266 (71) | 502 (69) |
| Severity of consumption (units/week)* | | | |
| 1–2 | 1006 (66) | 486 (98) | 153 (91) |
| 3–7 | 367 (25) | 11 (2) | 10 (6) |
| 8–14 | 93 (6) | 1 (0.2) | 5 (3) |
| >14 | 23 (2) | 0 | 1 (1) |
| Median (IQR) | 1 (1, 2) | 0.5 (0.3, 1.0) | 1 (1, 1) |
| Binge second trimester (yes) | *Not recorded* | 7 (0.4) | 4 (1) |
| Third trimester alcohol consumption | 1559 (14) | *Not recorded* | 225 (32) |
| Non-drinkers in third trimester | 9394 (84) | *No recorded* | 493 (68) |
| Severity of consumption (units/week)* | | | |
| 1–2 | 1016 (70) | *Not recorded* | 161 (90) |
| 3–7 | 341 (23) | *Not recorded* | 13 (7) |
| 8–14 | 78 (5) | *Not recorded* | 4 (2) |
| >14 | 21 (1) | *Not recorded* | 1 (1) |
| Median (IQR) | 1 (1, 2) | *Not recorded* | 1 (1, 1) |
| Binge third trimester (yes) | *Not recorded* | *Not recorded* | 6 (1) |

*Note that severity of alcohol consumption only refers to women who consumed alcohol during pregnancy.
GUI, Growing up in Ireland; PRAMS, Pregnancy Risk Assessment Monitoring System; SCOPE, Screening for Pregnancy Endpoints.

was the only consistent predictor of alcohol use across all cohorts and countries examined.

To the best of our knowledge, this is the first cross-cohort comparison of the prevalence and predictors of alcohol use during pregnancy. Our study goes beyond measurement of alcohol use during pregnancy with just one cohort or one measurement method, but examines prevalence and predictors using different measurement techniques in the same population. It also examines variation in prevalence keeping measurement constant across different settings. The study had a large sample size of almost 18 000 women. We were able to examine prevalence using different modes of administration (anonymised self-administered postal survey in PRAMS, trained government interview in GUI, antenatal midwife-collected data in SCOPE) and timing of administration (2–9 months postpartum in PRAMS, 9–12 months postpartum in GUI, and in the second trimester of pregnancy in SCOPE). However, as we used self-reported alcohol consumption data, reporting and recall biases may exist, and where the true estimate lies (ranging from 20% in GUI to 80% in SCOPE) is unclear. Our findings of reduced alcohol consumption in women who had low birth weight infants in both the retrospective studies may suggest differential recall bias among women with adverse birth outcomes, since similar evidence was not

Table 3 Log linear binomial regression for risk of alcohol during pregnancy

| | GUI n=10 953 Adjusted RR (95% CI) | SCOPE Ireland n=1766 Adjusted RR (95% CI) | PRAMS n=718 Adjusted RR (95% CI) |
|---|---|---|---|
| Age (years) | | | |
| <20 | 0.48 (0.30 to 0.77) | 0.92 (0.85 to 1.00) | 1.31 (0.42 to 4.14) |
| 20–24 | 0.56 (0.46 to 0.68) | 0.84 (0.71 to 0.99) | 0.26 (0.09 to 0.77) |
| 25–29 | 0.69 (0.62 to 0.78) | 0.95 (0.91 to 1.00) | 0.84 (0.66 to 1.08) |
| 30–39 | Reference | Reference | Reference |
| >40 | 1.18 (1.04 to 1.35) | 0.86 (0.66 to 1.10) | 0.97 (0.67 to 1.39) |
| Education* | | | |
| Secondary | 0.65 (0.60 to 0.72) | 0.94 (0.88 to 1.01) | 0.81 (0.62 to 1.07) |
| Tertiary | Reference | Reference | Reference |
| Ethnicity | | | |
| Caucasian | Reference | Reference | Reference |
| Other | 0.27 (0.19 to 0.37) | 0.34 (0.20 to 0.56) | 0.31 (0.11 to 0.88) |
| Marital status | | | |
| Married | Reference | Reference | Reference |
| Single | 1.05 (0.96 to 1.17) | 1.09 (1.02 to 1.17) | 0.98 (0.65 to 1.47) |
| Parity | | | |
| 0 | Reference | – | Reference |
| 1+ | 0.90 (0.83 to 0.98) | – | 1.02 (0.86 to 1.21) |
| Smoking | | | |
| Yes | 1.50 (1.36 to 1.65) | 1.17 (1.12 to 1.22) | 1.42 (1.18 to 1.70) |
| No | Reference | Reference | Reference |
| BMI (kg/m$^2$) | | | |
| <18.5 | 1.01 (0.79 to 1.29) | 1.06 (0.86 to 1.30) | 0.80 (0.46 to 1.41) |
| 18.5–24.99 | 0.98 (0.90 to 1.07) | 1.02 (0.97 to 1.07) | 0.96 (0.78 to 1.18) |
| 25.0–29.9 | Reference | Reference | Reference |
| >30 | 0.84 (0.74 to 0.94) | 0.96 (0.89 to 1.04) | 0.89 (0.63 to 1.27) |
| Low birth weight (<2500 g) | | | |
| No | Reference | Reference | Reference |
| Yes | 0.76 (0.60 to 0.96) | 1.01 (0.89 to 1.14) | 0.66 (0.36 to 1.22) |
| Preterm birth (<37 weeks gestation) | | | |
| No | Reference | Reference | Reference |
| Yes | 0.91 (0.74 to 1.12) | 0.94 (0.83 to 1.07) | 0.97 (0.56 to 1.66) |

Log linear binomial regression was used to examine the characteristics associated with alcohol consumption in each cohort and adjusted for all variables in table.
*Secondary includes all education up to university or post school institutions. Tertiary includes any tertiary education at a university or other post school institution.
BMI, body mass index; GUI, Growing up in Ireland; PRAMS, Pregnancy Risk Assessment Monitoring System; SCOPE, Screening for Pregnancy Endpoints.

found in the prospective SCOPE cohort where data was collected concurrently before women knew the outcome of their pregnancy. Estimates of prevalence may vary across the studies, in part, due to methodological differences in the assessment of alcohol related to the nature, content and timing of questions. The interaction of these methodological differences with a participant's desire to report in a socially desirable way may also explain variation in reporting across studies. For example, in the GUI cohort, women may have under-reported to a greater extent due to the influence of social desirability in the presence of a trained government interviewer. This contrasts with potentially better reporting of alcohol consumption in the anonymised PRAMS postal questionnaire. Therefore, variation in prevalence across the cohorts is likely to be driven by sociodemographic differences in the cohorts which influence true consumption levels, as well as measurement and reporting differences across the studies. Additionally, we have only included live born babies in our analysis and thus, there is a possibility that we have excluded women with the heaviest drinking patterns, since failure to give birth to a baby could have resulted from heavy drinking; for example, miscarriage occurring due to early pregnancy chronic alcohol use or binge drinking. Participants in our studies may also be more advantaged than the general population and thus, the generalisability of our findings to all pregnancies or more diverse populations may be reduced. Nonetheless, the cross-cohort comparison improves upon previously published single cohort analyses, since it shows gestational alcohol use to be prevalent and socially pervasive during pregnancy, as

Table 4 Comparison of alcohol use in SCOPE Centre's

| | Total n=5573 | New Zealand n=2006 | Ireland n=1766 | Australia n=1150 | UK* n=651 | p Value |
|---|---|---|---|---|---|---|
| Pre-pregnancy alcohol consumption | 4319 (77) | 1552 (77) | 1586 (90) | 539 (53) | 540 (83) | <0.001 |
| Non-drinkers pre-pregnancy | 1254 (23) | 454 (23) | 180 (10) | 611 (47) | 111 (17) | |
| Severity of consumption (units/week)† | | | | | | |
| 1–2 | 1126 (26) | 503 (32) | 287 (18) | 232 (38) | 104 (19) | <0.001 |
| 3–7 | 1674 (39) | 698 (45) | 602 (38) | 211 (34) | 163 (30) | |
| 8–14 | 963 (22) | 253 (16) | 451 (28) | 94 (15) | 165 (31) | |
| >14 | 528 (12) | 98 (6) | 246 (16) | 76 (12) | 108 (20) | |
| Median (IQR) | 5 (2, 10) | 4 (2, 7) | 6 (3, 11) | 4 (1, 8) | 7.5 (3, 13) | <0.001 |
| Pre-pregnancy binging | 1741 (31) | 337 (17) | 1044 (59) | 123 (11) | 247 (38) | <0.001 |
| Any alcohol in pregnancy | 3482 (63) | 1107 (56) | 1444 (82) | 459 (40) | 476 (75) | <0.001 |
| Non-drinkers in pregnancy | 2091 (37) | 899 (44) | 322 (18) | 691 (60) | 175 (25) | |
| Binge (any in pregnancy) | 1282 (23) | 167 (9) | 795 (45) | 113 (10) | 207 (33) | <0.001 |
| First trimester alcohol consumption | 3370 (60) | 1063 (53) | 1415 (80) | 440 (38) | 451 (69) | <0.001 |
| Non-drinking in first trimester | 2203 (40) | 943 (47) | 171 (20) | 710 (62) | 200 (61) | |
| Severity of consumption (units/week)† | | | | | | |
| 1–2 | 1078 (32) | 361 (34) | 424 (30) | 142 (32) | 151 (34) | <0.001 |
| 3–7 | 1372 (41) | 463 (44) | 600 (42) | 158 (36) | 151 (34) | |
| 8–14 | 624 (19) | 175 (16) | 266 (19) | 80 (18) | 103 (23) | |
| >14 | 296 (9) | 65 (6) | 125 (9) | 60 (14) | 46 (10) | |
| Binge first trimester | 1279 (23) | 167 (8) | 795 (45) | 111 (10) | 206 (32) | <0.001 |
| Median (IQR) | 4 (2, 8) | 4 (2, 7) | 4 (2, 7.5) | 5 (2, 10) | 4 (1.9, 9) | 0.020 |
| Second trimester alcohol consumption | 1018 (19) | 232 (12) | 500 (29) | 73 (7) | 213 (34) | <0.001 |
| Non-drinking in second trimester | 4555 (81) | 1774 (88) | 1266 (71) | 1077 (83) | 438 (66) | |
| Severity of consumption (units/week)† | | | | | | |
| 1–2 | 976 (97) | 220 (97) | 486 (98) | 68 (93) | 202 (96) | 0.3 |
| 3–7 | 30 (3) | 7 (3) | 11 (2) | 4 (5) | 8 (4) | |
| 8–14 | 3 (0.3) | 0 | 1 (0.2) | 1 (1) | 1 (0.5) | |
| >14 | 0 | 0 | 0 | 0 | 0 | |
| Binge second trimester | 18 (0.4) | 2 (0.1) | 7 (0.4) | 6 (1) | 3 (1) | 0.2 |
| Median (IQR) | 0.5 (0.3, 1) | 0.5 (0.3, 1) | 0.5 (0.3, 1) | 0.5 (0.1, 1) | 0.8 (0.5, 1.5) | <0.001 |

All data are N (%) unless otherwise stated. Median difference between centres tested using Kruskall-Wallis test. All other differences tested with $\chi^2$ test for categorical variables.
*London, Manchester, Leeds.
†Note that severity of alcohol consumption only refers to women who consumed alcohol during pregnancy.
IQR, interquartile range; SCOPE, Screening for Pregnancy Endpoints.

measured by various measurement methods and in different settings. Second, across different studies and settings, maternal smoking is a strong and consistent predictor of alcohol consumption in pregnancy. Additionally, from a methodological perspective, the analysis points to the need for an agreed convention by which to measure gestational alcohol use to avoid substantial variation and heterogeneity in estimates and predictors of gestational alcohol use in future studies.

Our findings of a range of gestational alcohol use from 20 to 80% are largely consistent with studies of similar design for each cohort, respectively. In general, prospective ascertainment of exposure has been shown to be more accurate than retrospective reporting where it has been suggested that postpartum drinking levels and poorer memory after the fact could influence reporting.[17] In the prospective SCOPE study, the high rates of pre-pregnancy and gestational alcohol consumption that were observed in Ireland are compatible with estimates from another large contemporary prospectively recruited urban Irish cohort (n=65 000) which had a similar prospective design but with both nulliparous and multiparous participants.[18] However, GUI estimates are likely to substantially underestimate gestational alcohol consumption, especially when compared with 37% alcohol prevalence in the UK MCS, a cohort of almost identical design where exposure was measured 9 months postpartum.[6] Potential reasons why GUI and MCS estimates are not compatible include differences in interviewing techniques and administration of surveys which would easily influence reporting of socially undesirable behaviours such as gestational alcohol use. Alternately, the retrospective PRAMS estimate of alcohol consumption of almost 50% in pregnancy is comparable with estimates from a number of large European cohorts including Generation R,[19] the Danish National Birth cohort,[20] MCS[6] and another recent prospective cohort from Leeds in the UK.[21] This suggests that the retrospective component in itself may not always result in an underestimation of alcohol use. Throughout much of the literature, it is

Table 5 Log linear binomial regression for risk of alcohol consumption during pregnancy in SCOPE

| | New Zealand n=2006 Adjusted RR (95% CI) | Ireland n=1766 Adjusted RR (95% CI) | Australia n=1150 Adjusted RR (95% CI) | UK* n=651 Adjusted RR (95% CI) |
|---|---|---|---|---|
| Age (years) | | | | |
| <20 | 0.78 (0.66 to 0.93) | 0.92 (0.85 to 1.00) | 0.94 (0.75 to 1.17) | 1.02 (0.90 to 1.16) |
| 20–24 | 0.74 (0.56 to 0.97) | 0.84 (0.71 to 0.99) | 0.90 (0.70 to 1.16) | 0.86 (0.69 to 1.07) |
| 25–29 | 0.83 (0.76 to 0.91) | 0.95 (0.91 to 1.00) | 1.03 (0.81 to 1.30) | 0.93 (0.84 to 1.03) |
| 30–39 | Reference | Reference | Reference | Reference |
| >40 | 0.71 (0.52 to 0.98) | 0.86 (0.66 to 1.10) | 1.33 (0.63 to 2.84) | 0.77 (0.45 to 1.33) |
| Education† | | | | |
| Secondary | 0.84 (0.74 to 0.96) | 0.94 (0.88 to 1.01) | 0.96 (0.82 to 1.11) | 0.93 (0.79 to 1.09) |
| Tertiary | Reference | Reference | Reference | Reference |
| Ethnicity | | | | |
| Caucasian | Reference | Reference | Reference | Reference |
| Other | 0.67 (0.58 to 0.78) | 0.34 (0.20 to 0.56) | 0.77 (0.58 to 1.03) | 0.57 (0.46 to 0.71) |
| Marital status | | | | |
| Married | Reference | Reference | Reference | Reference |
| Single | 1.22 (1.02 to 1.46) | 1.09 (1.02 to 1.17) | 1.07 (0.89 to 1.29) | 1.08 (0.93 to 1.26) |
| Smoking | | | | |
| Yes | 1.50 (1.36 to 1.66) | 1.17 (1.12 to 1.22) | 1.82 (1.57 to 2.11) | 1.15 (1.05 to 1.27) |
| No | Reference | Reference | Reference | Reference |
| BMI (kg/m$^2$) | | | | |
| <18.5 | 0.88 (0.55 to 1.41) | 1.06 (0.86 to 1.30) | 0.76 (0.47 to 1.22) | 0.67 (0.31 to 1.44) |
| 18.5–24.99 | Reference | Reference | Reference | Reference |
| 25.0–29.9 | 1.01 (0.93 to 1.10) | 1.02 (0.97 to 1.07) | 1.18 (1.00 to 1.38) | 0.98 (0.88 to 1.08) |
| >30 | 0.86 (0.75 to 1.00) | 0.96 (0.89 to 1.04) | 0.84 (0.70 to 1.01) | 0.85 (0.73 to 1.00) |
| Low birth weight (<2500 g) | | | | |
| No | Reference | Reference | Reference | Reference |
| Yes | 0.94 (0.76 to 1.18) | 1.01 (0.89 to 1.14) | 1.29 (0.88 to 1.89) | 1.22 (0.86 to 1.73) |
| Preterm birth (<37 weeks gestation) | | | | |
| No | Reference | Reference | Reference | Reference |
| Yes | 0.81 (0.65 to 1.00) | 0.94 (0.83 to 1.07) | 1.02 (0.73 to 1.42) | 1.08 (0.79 to 1.49) |

Log linear binomial regression was used to examine the characteristics associated with alcohol consumption in each cohort and adjusted for all variables in table.
*London, Manchester, Leeds.
†Secondary includes all education up to university or post school institutions. Tertiary includes any tertiary education at a university or other post school institution.
BMI, body mass index; SCOPE, Screening for Pregnancy Endpoints.

widely shown and accepted that face-to-face interviews are often the 'gold standard' in epidemiological research. However, in relation to more subjective issues which could be biased by social desirability, self-administered questionnaires may elicit better quality data.[22] In our cross-cohort comparison, estimates of alcohol prevalence in the face-to-face GUI survey were considerably lower than in PRAMS, a finding which would support the superiority of self-administered questionnaires in measuring more subjective issues such as alcohol use. However, since reporting of other socially undesirable behaviours during the perinatal period in GUI was high (eg, 18% of smoking in pregnancy), it is possible that low reporting of alcohol prevalence in GUI could be explained by true population differences in prevalence of alcohol use in pregnancy. Finally, our results for other SCOPE centres, such as the UK, are higher than some British birth cohorts,[6 7] but generally consistent with the high prevalence reported in other large studies, such as ALSPAC.[7] SCOPE Australia and New Zealand estimates also appear to be reasonably consistent with some previous data in the region.[23–26]

The findings of this study have direct application to policy and practice. Alcohol use during pregnancy is highly prevalent, and evidence from this cross-cohort and cross-country comparison shows that gestational alcohol exposure may occur in over 75% of pregnancies in the UK and Ireland. Although low proportions of women engaged in heavy drinking, the adverse consequences of heavy alcohol consumption during pregnancy on birth outcomes, long-term gross motor function,[27] and social, cognitive, emotional and behavioural outcomes[28] in offspring make heavy gestational alcohol consumption a high public health priority. Additionally, since most women who consume alcohol do so at lower levels where the offspring growth[29] and development effects are less well understood,[30] the widespread consumption of even low levels of alcohol during

pregnancy is a significant public health concern. As we do not find compelling evidence that alcohol use is more prevalent in any particular sociodemographic group, for example, in single or less well educated women which were also shown in a recent systematic review to be inconsistently related to alcohol use during pregnancy,[31] healthcare professionals should continue to advise all pregnant women to abstain from alcohol during pregnancy in line with best practice clinical care guidelines, irrespective of professionally perceived risk of exposure. Given evidence of higher risk of drinking during pregnancy among smokers which was consistent across cohorts and within countries examined, and which is also consistent with recent evidence of increased drinking among smokers in other cohorts,[32–34] dual targeting of smoking and alcohol consumption should potentially be increased and delivered routinely upon a woman's indication of either behaviour during pregnancy. New policy and interventions are also required to reduce alcohol prevalence both prior to and during pregnancy.

This cross-cohort comparison highlights the urgent need for a biological marker of gestational alcohol use, since it is difficult to estimate to what extent estimates and their predictors are plausible even in more robust study designs (prospective measurement being the most superior), and when data is analysed in a comparative design such as ours. Additionally, this research highlights the need for a clear convention and standard method of measurement of alcohol use across observational studies which minimises heterogeneity in measurement, insofar as is possible using self-reported measurement of socially undesirable behaviours. Population differences in actual alcohol consumption are a plausible reason for variation in prevalence. However, variation in measurement methods may also explain differing prevalence and predictors, such as differences in interviewing techniques of SCOPE midwives across centres. Another potential reason for variation in reporting, or indeed actual alcohol use, may include variation in professional and patient attitudes to the acceptability of alcohol consumption during pregnancy, such that propensity to report alcohol use or consume alcohol during pregnancy would be easily influenced by a combination of measurement method, cultural attitudes to alcohol and social desirability, thereby underscoring the need for objective measures of gestational alcohol use.

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**Contributors** LMO'K had the original idea for the study, wrote the first draft of the article, applied critical revisions to the article based on other coauthor recommendations, and approved the final version for publication. PMK, FM and ASK conceptualised the design of the study with other coauthors, assisted in interpretation of the data, reviewed and revised the manuscript and approved the final version for publication. RAG conceptualised the design of the study, assisted in the interpretation of the data, contributed to critical revisions of the article, and approved the final version for publication. RAN, LP, LMEM, PNB, GAD, JJW and RT conceptualised the design of the study, contributed to critical revisions of the article and approved the final version for publication. LCK supervised the write up of the manuscript, contributed to critical revisions of the article and approved the final version for publication.

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